

Luminescence Properties of YF₃:Gd,Pr under Vacuum Ultraviolet Excitation

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We have investigated an ultraviolet (UV) phosphor that is suitable for excitation by the vacuum ultraviolet (VUV) light, which is used in mercury-free applications such as a xenon discharge fluorescent lamp. It is interesting that the UV light, for example, has the benefit of photocatalysis for titanium oxide. At present, the emission intensity of the conventional UV phosphors is not enough under VUV excitation. Therefore, the phosphors with high quantum efficiency are quite needed.

It is well known that photoemissions of Gd³⁺ ion are observed in the UV regions [1]. The excited energy levels within the 4f⁷ configuration of Gd³⁺ ions exist above 32000 cm⁻¹ and the corresponding transitions have low oscillator strength for the parity selection rule [2]. In addition, excited 4f⁶5d levels of Gd³⁺ are predicted to be at very high energy levels (> 70000 cm⁻¹) [3]. Therefore, it is necessary to put in a sensitizer in case of using the UV phosphor. Here we report our results on luminescence properties of Pr³⁺ sensitizer and Gd³⁺ activator doped YF₃ for VUV regions.

Figure 1 shows the emission and excitation spectra of YF₃:Gd,Pr at room temperature. The emission spectrum obtained under excitation at 172-nm light consists of a strong peak-emission line at 311 nm and a weak emission band around 407 nm. At present, the emission intensity of the 311-nm is about 10 times as strong as for conventional UV phosphors. The 311-nm emission is effectively stimulated under excitation in the range from 150 to 200 nm. This excitation spectrum is also the same for 407-nm emission.

The energy level diagram for a Pr³⁺-Gd³⁺ system is shown in Fig. 2 [3-5]. It is clear that the 311-nm emission line is originated from ⁶P_{7/2} to ⁸S_{7/2} transition of the Gd³⁺ ion [6] and the 407-nm emission from ¹S₀ to ¹I₆ of the Pr³⁺ ion [7,8]. In the region of VUV, the absorption strength of the Gd³⁺ ion is quite weak because the 4f-4f transitions are forbidden. Therefore, it is concluded that the excitation of VUV regions in YF₃:Gd,Pr corresponds to the 4f²-4f5d transitions in Pr³⁺ ion. On the other hand, GdBO₃:Pr³⁺ phosphor was reported by Srivastava and Vries [9,10]. It was found that a large part of the excited energy was transferred from Pr³⁺ to Gd³⁺ ions. These results suggest that the strong emission at 311 nm is due to the 4f²-4f5d allowed transitions of Pr³⁺ ion and a highly efficient transfer of energy from Pr³⁺ to Gd³⁺ ions.

The process of energy transfer between these ions will be discussed in detail on the basis of the present results as well as those of the decay time measurement.

Reference

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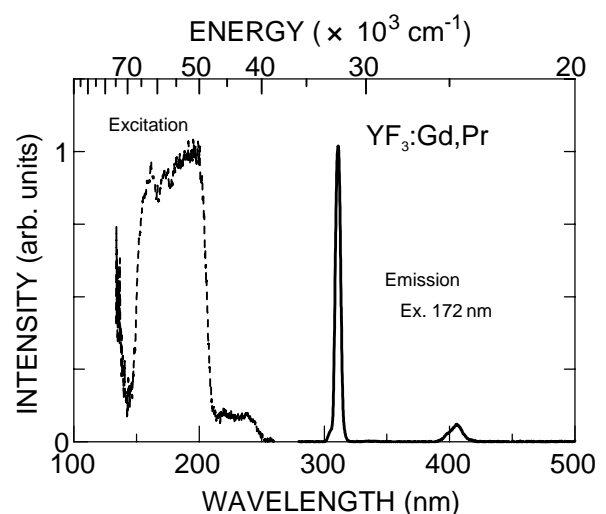


Figure 1 The emission spectrum of YF₃:Gd,Pr under the excitation of 172-nm light (right side) and the excitation spectrum for the 311-nm emission line (left side).

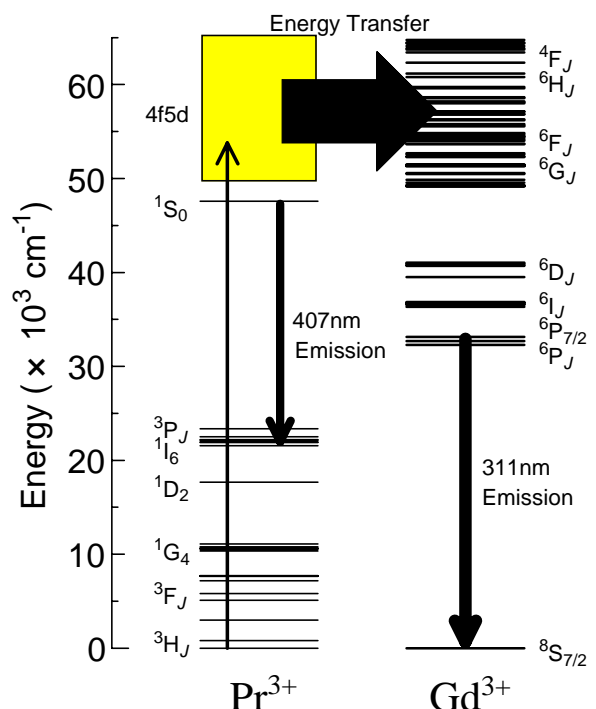


Figure 2 Energy level diagram for a Pr³⁺-Gd³⁺ system.